

New Taxa and a New Rank of *Selaginella* (Selaginellaceae) from Madagascar and the Comoros

Saša Stefanović and France Rakotondrainibe

École Pratique des Hautes études, Laboratoire de Phytomorphologie, Muséum National d'Histoire Naturelle, 16, rue Buffon, F-75005 Paris, France

ABSTRACT. Two new species of *Selaginella* from Madagascar, *S. bemarahensis* and *S. marinii*, are described and illustrated, as are a new subspecies of *S. nivea* Alston and a new form of *S. fissidentoides* (Hooker & Greville) Spring var. *fissidentoides*. The Malagasy species *S. fissidentoides* is segregated into two varieties, one of which has been previously known as *S. amphirrhizos* A. Braun ex Hieronymus. The taxonomic position and closest relationships of each taxon are briefly discussed.

The monogeneric family Selaginellaceae comprises about 700 species distributed throughout the world, but for the most part concentrated in tropical and subtropical areas. The most recent infrageneric classification of the genus *Selaginella* (Jermy, 1986) recognized five subgenera.

The last complete account of the family in Madagascar and the Comoros was made by A. H. G. Alston (1932), who listed eleven species of *Selaginella* as occurring in that area. Two additional Malagasy species were established, one by R. M. Tryon (1955) and one by W. Rauh and W. Hagemann (1991). During revision of this family for the *Flore de Madagascar et des Comores*, made possible by increased collecting in the last 40 years (specimens have been studied from B, BM, K, P), one existing taxon has been divided and four distinct taxa have been noted. They are described in this paper, so that the names can be used in the Flora treatment. Two species, *S. bemarahensis* and *S. marinii*, belong to the subgenus *Heterostachys* Baker, and one subspecies, *S. nivea* subsp. *humbertii*, to the subgenus *Tetragonostachys* Jermy. *Selaginella fissidentoides* var. *amphirrhizos* and *S. fissidentoides* fo. *ovata* (of var. *fissidentoides*) belong to the subgenus *Stachygynandrum* (P. Beauvois) Baker.

At present, fifteen species of *Selaginella* are recognized in Madagascar and the Comoros, one of them represented by two subspecies and one by two varieties and one form.

The descriptive terms referring to shape, surface, and structure of spores follow terminology used by A. F. Tryon and B. Lugardon (1991).

1. *Selaginella bemarahensis* S. Stefanović & Rakotondrainibe, sp. nov. TYPE: Madagascar. Mahajanga: Reserve Naturelle de Bemaraha, au sud-est d'Antsalova, 18°45'S, 44°48'E, 400 m, 23 Aug. 1987, Phillipson 2257 (holotype, P; isotype, MO not seen). Figure 1A, B.

Species haec, inter species subgeneris *Heterostachys* Baker, habitu parvulo et muscoso ad *S. perpusillam* Baker accedens, sed foliis lateralibus et medianis similaribus (praeter staturam), foliorum mediorum apice acuto et foliorum lateralium marginibus et sporophyllorum ventralium denticulatis (non ciliatis) ab ea differt.

Plants tiny, moss-like, slender, without rhizome, forming mats. Main stem suberect to erect, 2–4.5 cm long, outline lanceolate, rarely or not branched, provided with rhizophores. Branches, when present, short and unbranched. Rhizophores dorsal, situated on the lower half of the stem, 2–8 mm long and very fine, straw-yellow, dichotomizing 2–3 times. Leaves dimorphic, pale green, herbaceous, widely spaced on the main stem, contiguous toward the tips of the main stem and branches. Lateral leaves subequal, lanceolate, 1.8–3 mm long, 0.6–1 mm wide, midrib apparent, base symmetrical and blunt, apex acute, margin subentire to denticulate all around the leaf. Axillary leaves similar to lateral but equal. Median leaves also similar to lateral leaves but smaller, 1.2–1.8 mm long, 0.5–0.8 mm wide. Strobili solitary, inserted terminally on main stem and branch tips, bilateral, resupinate, 5–8 mm long and 1.5–2 mm wide. Sporophylls dimorphic, spreading, margins denticulate. Dorsal sporophylls ovate-lanceolate, 1–1.5 mm long and 0.4–0.6 mm wide, keeled, keel well developed and denticulate, base blunt, apex acute. Ventral sporophylls ovate, 0.9–1.1 mm long and 0.4–0.6 mm wide, slightly or not keeled, base blunt, apex acute-acuminate. Megaspores light lemon yellow, 278–287 μm diam., spherical, trilete, with laesura nearly equaling the radius, surface finely tuberculate on both proximal and distal face (Fig. 2A). Microspores bright orange, 35–38 μm diam., tetrahedral-globose, trilete, with laesura nearly equaling the radius, surface laevigate to finely granulate on both proximal and

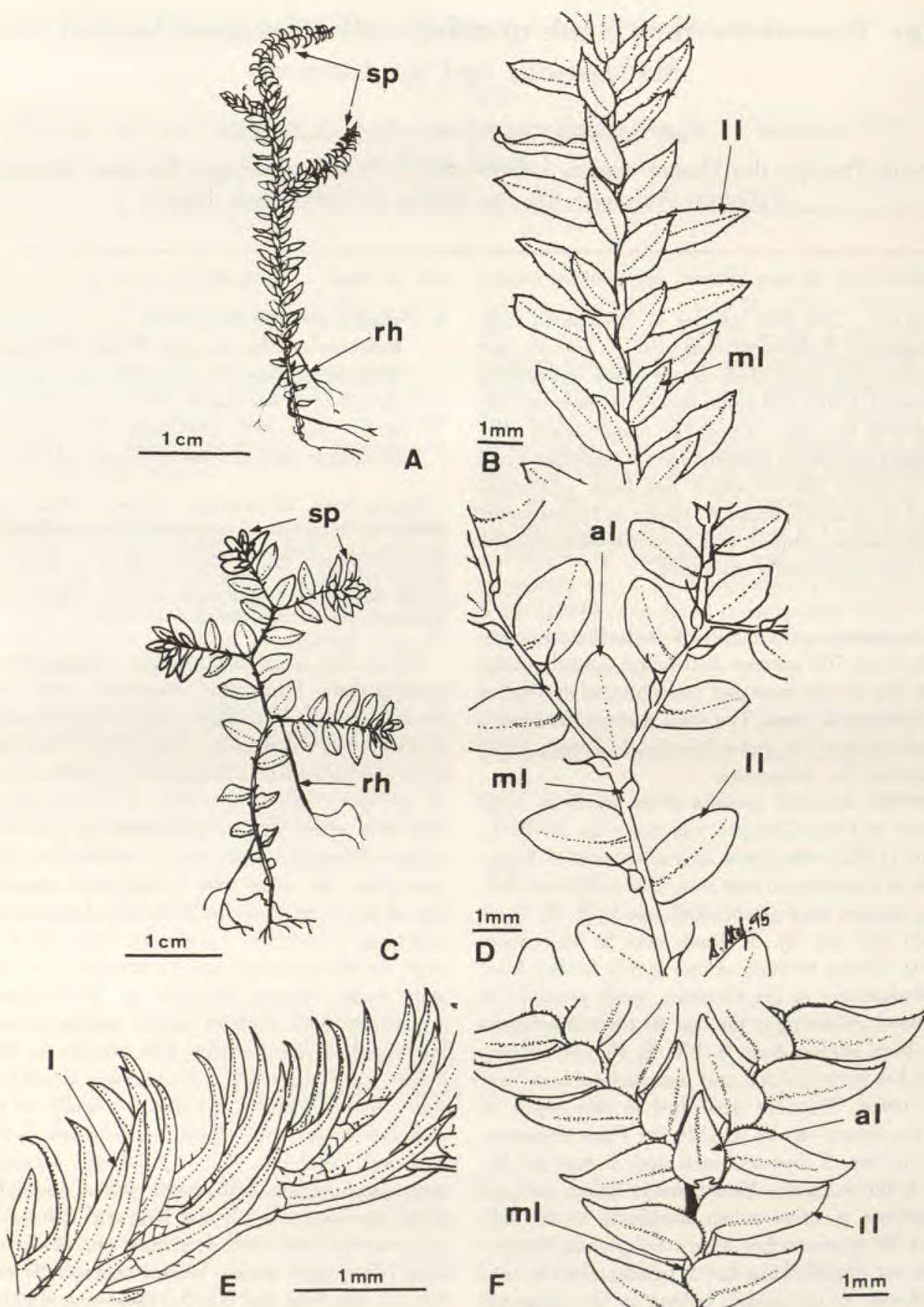


Figure 1. —A, B. *Selaginella bemarahrensis* S. Stefanović & Rakotondrainibe (holotype, P). Habit (A) and the dorsal view detail (B) showing the similarity of the lateral and median leaves. —C, D. *Selaginella marinii* S. Stefanović & Rakotondrainibe (holotype, P). Habit (C) and the dorsal view detail (D) showing widely spaced leaves and the characteristic, very small median leaves. —E. *Selaginella nivea* Alston subsp. *humbertii* S. Stefanović & Rakotondrainibe (holotype, P). Enlarged detail showing the leaves without a seta at the apex. —F. *Selaginella fissidentoides* (Hooker & Greville) Spring fo. *ovata* S. Stefanović & Rakotondrainibe (holotype, P). Enlarged ventral view detail showing lateral and axillary leaves. Legend: al = axillary leaves; l = leaves (uniform); ll = lateral leaves; ml = median leaves; rh = rhizophores; sp = sporophylls of strobili.

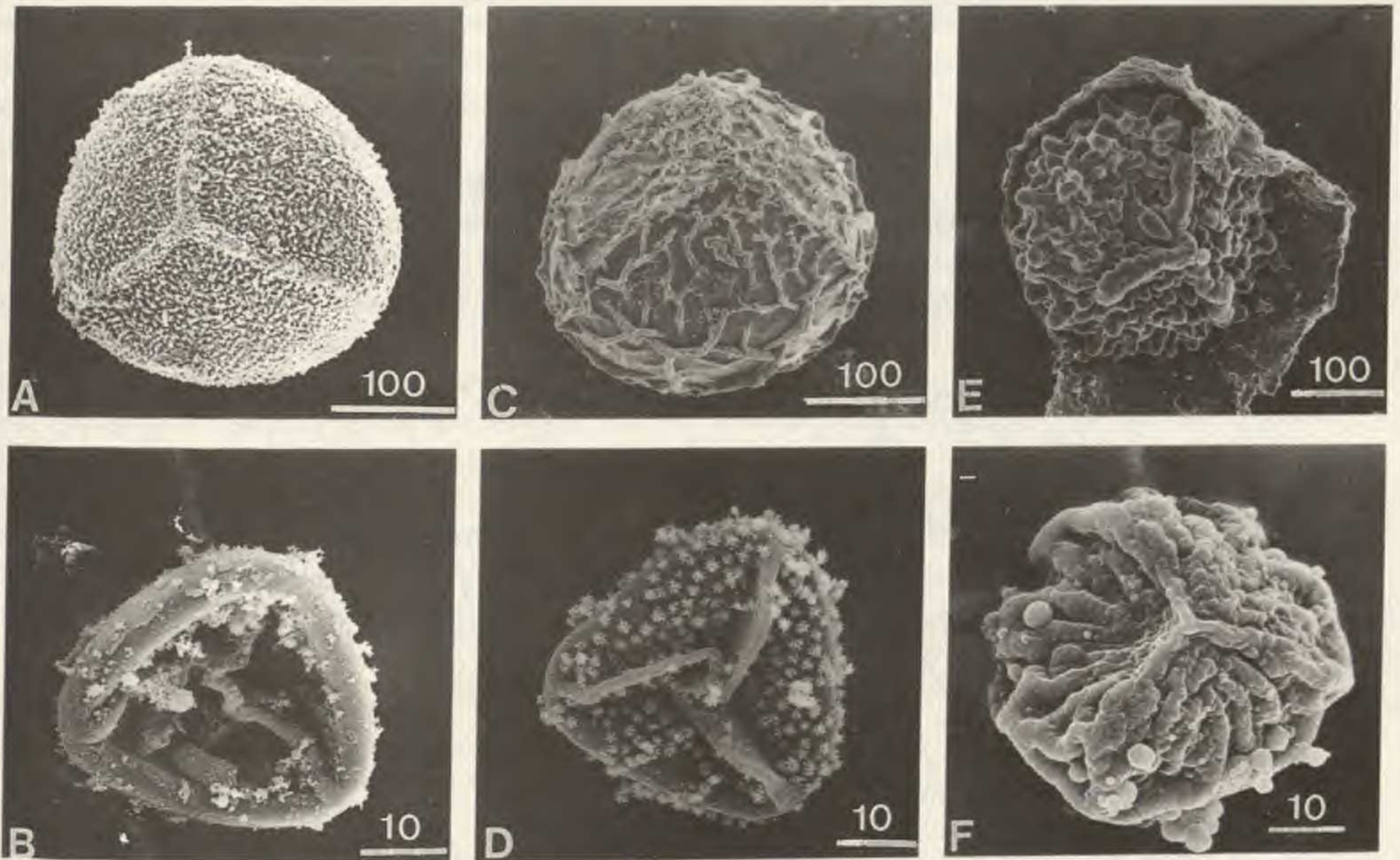


Figure 2. Scanning electron (SEM) micrographs of the spores from holotype specimens (scale bars in μm). —A. Megaspore of *S. bemarahensis*. —B. Microspore of *S. bemarahensis*. —C. Megaspore of *S. marinii*. —D. Microspore of *S. marinii*. —E. Megaspore of *S. nivea* subsp. *humbertii*. —F. Microspore of *S. nivea* subsp. *humbertii*.

distal face, with amorphous background pattern (Fig. 2B).

Both known collections of this species are from central-west Madagascar, Reserve Naturelle de Bemaraha, where the species grows on rocks and mud banks in shade along streams, at an elevation of about 400–500 m (Fig. 3A). The species is named after the type locality.

Following the taxonomic arrangement of the genus *Selaginella* proposed by Jermy (1986), *S. bemarahensis*, through its bilateral and resupinate strobili and dimorphic sporophylls, belongs to the subgenus *Heterostachys* Baker.

Selaginella bemarahensis is characterized by the striking similarity of its lateral and median leaves (except in size), a feature that is rare among species of this subgenus. *Selaginella perpusilla* Baker (an African and Malagasy species), like *S. bemarahensis*, is a very small, moss-like plant, rarely branched, with relatively large strobili. It differs from *S. bemarahensis* in its deltoid outline, more unequal lateral leaves with ciliate upper margins, acuminate median leaves, more compact strobili, and ciliate ventral sporophylls.

Paratype. MADAGASCAR. 12 km à l'est-sud-est d'Ankiliromotsy, 26 km au sud-est d'Antsalova, 30 Mar. 1993, Villiers, Klackenberg & Badré 4995 (P).

2. *Selaginella marinii* S. Stefanović & Rakotondrainibe, sp. nov. TYPE: Madagascar. Antsiranana: Reserve Speciale de Manongarivo, Mt. Antsatroto, 14°06'S, 48°25'E, 1220 m, 20 May 1992, Rakotondrainibe 1677 (holotype, P). Figure 1C, D.

Species haec, inter species subgeneris *Heterostachys* Baker, habitu, foliorum lateralium marginibus denticulatis vel integris et foliorum mediorum apice acuminato ad *S. hildebrandtii* A. Braun ex Hieronymus similis, sed foliorum mediorum marginibus integris (non dentatis), foliorum lateralium foliis medianis valde minoribus et sporophyllorum ventralium marginibus ciliatis (non dentatis) differt.

Plants slender, without rhizomes, forming mats. Main stem suberect to erect, 3–8 cm long, outline lanceolate, branched, provided with rhizophores. Branches bifurcated 1–2 times. Rhizophores dorsal, situated on the lower half of the stem, 0.5–2 cm long and very fine, straw yellow to pale green, dichotomizing 2–3 times. Leaves dimorphic, metallic pale green, herbaceous, widely spaced to narrowly spaced, frequently appearing to be grouped in pairs, midrib slightly or not apparent. Lateral leaves subequal, oblong, 1.5–2.6 mm long, 0.7–1.3 mm wide, base asymmetrical and blunt, apex acute, margin subentire to denticulate all around the leaf. Axillary leaves similar to lateral leaves but equal. Median leaves subequal, lanceolate, very small,

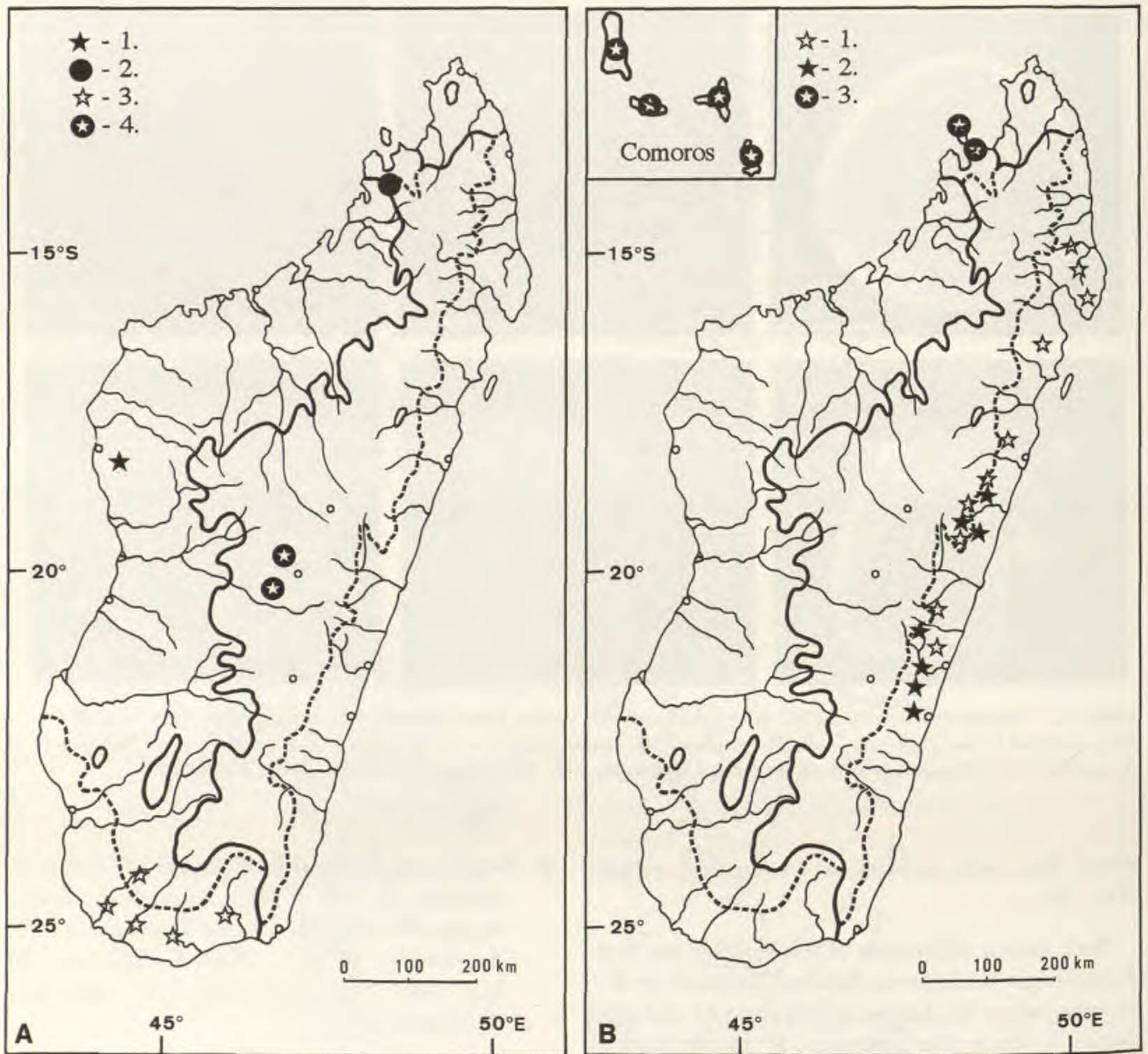


Figure 3. Map of Madagascar. Legend: full bold lines and dashed lines show major phytogeographic division (for more details, see H. Humbert, 1955). —A. Distribution of *S. bemarahrensis* (1), *S. marinii* (2), *S. nivea* subsp. *nivea* (3) and subsp. *humbertii* (4). —B. Distribution of *S. fissidentoides* fo. *fissidentoides* (1), fo. *ovata* (2), and var. *amphirrhizos* (3).

0.8–1.5 mm long and only 0.2–0.5 mm wide, base broadly cuneate, apex abruptly and long-acuminate, margins entire. Strobili solitary, inserted terminally on main stem and branch tips, bilateral, resupinate, 2–5 mm long and 3–4 mm wide. Sporophylls dimorphic. Dorsal sporophylls oblong-lanceolate, 1.6–2.1 mm long and 0.6–0.8 mm wide, keeled, keel slightly developed and hyaline, base blunt, apex acute, margins denticulate. Ventral sporophylls ovate, 0.9–1.2 mm long and 0.4–0.6 mm wide, slightly or not keeled, base blunt, apex gradually acuminate, margins ciliate. Megaspores pale yellow, 250–270 μm diam., tetrahedral-globose, trilete, with laesura equaling the radius, surface broken reticulate on both proximal and distal face, with finely echinulate background pattern (Fig. 2C).

Microspores brownish red, 32–38 μm diam., tetrahedral-globose, trilete, with laesura equaling the radius, surface laevigate on both proximal and distal face, with stellate crystal background pattern (Fig. 2D).

The three collections in existence so far are from Domaine Sambirano of northwest Madagascar, Reserve Speciale de Manongarivo, where the species grows in colonies on rocks in shade, at an elevation of 600–1300 m (Fig. 3A). The species is named after biologist Marin Vulić.

Based on its bilateral and resupinate strobili and dimorphic sporophylls this species also belongs to subgenus *Heterostachys* Baker.

The combination of widely spaced, spreading

leaves and the great difference in size between the lateral and median leaves frequently gives an impression that the leaves are grouped in pairs. This allows a new species to be easily recognized. *Selaginella marinii* resembles the Comorian species *S. hildebrandtii* A. Braun ex Hieronymus, both belonging to the same subgenus, in its lanceolate habit outline, shape of the lateral and median leaves, and acuminate median leaves. The two species can be distinguished by the median leaves and the ventral sporophylls. In *S. marinii* the median leaves are entire and very small compared to the laterals, and the ventral sporophylls are clearly ciliate. In *S. hildebrandtii*, however, the median leaves are dentate and about half the size of the laterals, and the ventral sporophylls are dentate.

Paratypes. MADAGASCAR. Manongarivo, Mt. Bekolasy, Apr.–June 1890, *Last 1890* (BM); Antsiranana, Reserve Speciale de Manongarivo, à l'est d'Ankaramy, Mt. Antsatrotro, 600–900 m, 26–30 Mar. 1993, *Malcomber, Rakotomalaza, Raharilala 2311* (P).

3. *Selaginella nivea* Alston ex Alston in C. Christensen, Dansk Bot. Ark. 7: 194, 1932.
TYPE: Madagascar. Environs d'Ampanihy, Sud-Ouest [domaine], June 1910, *Perrier de la Bâthie 8303* (holotype, BM; isotype, P).

Selaginella nivea was first mentioned by A. H. G. Alston, ms. in sched., then by H. Perrier de la Bâthie (Feb. 1932), nom. nud.; it was described and validated by A. H. G. Alston in June 1932.

The present study of this species shows that *Selaginella nivea* includes two distinct taxa that differ in some morphological features as well as in geographic distribution (subsp. *nivea* occurs at low elevations in southern Madagascar, whereas subsp. *humbertii* is found at much higher elevations in central Madagascar).

Because of its prostrate stems, spirally arranged and uniform leaves, tetragonal strobili, absence of rhizomes and stolons, as well as presence of rhizophores over the entire main stem, this species belongs to subgenus *Tetragonostachys* Jermy.

Selaginella nivea* Alston ex Alston subsp. *nivea

The type subspecies is characterized by its 1–2-cm-long dorsal rhizophores, generally ramified throughout their length; by its setae at the leaf apex, $\frac{1}{4}$ – $\frac{1}{3}$ as long as the blade; and by ciliate leaf margins with the longest cilia $\frac{1}{5}$ – $\frac{1}{4}$ as long as the width of the blade. Megaspores are light yellow, 391–402 μm diam., spherical, trilete, with laesura $\frac{1}{2}$ the radius, surface low tuberculate on proximal face, laevigate on distal face, very irregularly per-

forate on both faces. Microspores are light brown, 38–44 μm diam., tetrahedral-globose, trilete, with laesura $\frac{3}{4}$ to nearly equaling the radius, surface shortly irregularly striate on both proximal and distal face.

In Madagascar, *Selaginella nivea* subsp. *nivea* occurs only in the extreme south, on rocks in xerophilous bush (among *Euphorbia* spp. and *Didierea* spp.), at an elevation of 100–300 m (Fig. 3A). This subspecies is also known from a few localities in East Africa (Mozambique, Botswana, Zimbabwe).

***Selaginella nivea* Alston subsp. *humbertii* S. Stefanović & Rakotondrainibe, subsp. nov. TYPE:** Madagascar. Ouest Betsileo: à l'ouest de l'Itremo [Massif de l'Itremo, 20°36'S, 46°39'E], 1500–1700 m, 17–22 Jan. & 18–22 Apr. 1955, *Humbert 28366* (holotype, P). Figure 1E.

Subspecies haec a subspecies typica foliorum apice sine seta, ciliis longissimis $\frac{1}{6}$ – $\frac{1}{5}$ laminae latitudinis aequantibus et rhizophoris ramosis solum ad extremitates praecipue differt.

Plants with stems 7–10 cm long. Rhizophores dorsal, present throughout the main stem and branches, 3–5 cm long and 0.4 mm diam., dichotomizing only at their extremities. Main stem cylindrical, 0.5–0.8 mm diam. Leaves uniform, herbaceous, 1–1.5 mm long, 0.2–0.25 mm wide, apex acute to acuminate, without seta, margins dentate or ciliate toward the base of the leaf, the longest cilia $\frac{1}{6}$ – $\frac{1}{5}$ as long as the width of the blade. Megaspores light yellow, 314–419 μm diam., tetrahedral-globose, trilete, with laesura $\frac{3}{4}$ the radius, surface areolate verrucate on both proximal and distal face (Fig. 2E). Microspores light brown, 42–45 μm diam., tetrahedral-globose, trilete, with laesura equaling the radius, surface deeply striate on both proximal and distal face, striae regular and parallel with the laesura on proximal face, \pm irregular on distal face (Fig. 2F).

This taxon is known, so far, only from two localities in central Madagascar, Mt. Itremo and Mt. Ibity, where it grows on sheltered and westward slopes, on gneiss or quartz soil, at an elevation of 1600–2000 m (Fig. 3A). The subspecies is named in honor of the French botanist and great expert on the Malagasy flora, H. Humbert, who collected the type specimen.

Selaginella nivea subsp. *humbertii* differs mainly from the type subspecies in the absence of setae at the leaf apex and in the rhizophores dichotomizing only at their extremities. These macromorphological features combined with different spore surface pat-

terns and geographic distribution strongly support the present segregation into two taxa.

Paratypes. MADAGASCAR. Chaîne quartzitique de l'Iremo, 1700 m, Sep. 1956, *Bosser 9863* (P); chaîne à 6 km au sud de l'Iremo, 1700 m, Sep. 1956, *Bosser 9975* (P); sud-ouest Antsiraba, pentes du Mt. Ibity, vers 2000 m, 28 Mar. 1972, *Cremers 1975* (P); sud de l'Ibity, 2000 m, 14 Jan. 1973, *Guillaumet 4272* (P).

4. ***Selaginella fissidentoides*** (Hooker & Greville) Spring, Bull. Acad. Roy. Sci. Bruxelles 8 (12): 142. 1841. *Lycopodium fissidentoides* Hooker & Greville in Hooker, Bot. Misc. 2: 395. 1831. TYPE: Madagascar. *Lyall 267* (holotype, K).

This species, originally established by W. J. Hooker and R. K. Greville (1831) as *Lycopodium fissidentoides*, was transferred by A. H. G. Spring (1841) to the genus *Selaginella*. J. G. Baker (1883) placed in synonymy with *S. fissidentoides* another taxon, *S. amphirrhizos*, since according to him "*S. amphirrhizos* A. Braun, from Johanna Island, Hildebrandt 1808 [type], seems to be a luxuriant form of this species [*S. fissidentoides*]." *Selaginella amphirrhizos* was first mentioned by A. Braun, ms. in sched., then by M. Kuhn (1879) and C. Salomon (1883), nom. nud., and finally was described and validated as a new species by G. Hieronymus (1902). In his study on the species of *Selaginella* from Madagascar, A. H. G. Alston (1932) also treated these two taxa as synonyms, adding that "*S. amphirrhizos* has broader, more oblong lateral leaves than the typical form," as did C. F. Reed (1966) in his *Index Selaginellarum*.

The present study of *Selaginella fissidentoides* now shows that this species is comprised of three segregates (two varieties and one form). These taxa, one occurring in east central Madagascar (var. *fissidentoides*) and the other found only on the Comoros and Nossi-Bé (var. *amphirrhizos*), are treated here as varieties because of their well-defined and constant differences in morphology and in geographic distribution. One population belonging to variety *fissidentoides*, but differing in some morphological characters, is described as a new form.

Selaginella fissidentoides is the only Malagasy species of the subgenus *Stachygynandrum* Baker with creeping stems, prostrate branches, and rhizophores present over the entire main stem.

Selaginella fissidentoides (Hooker & Greville) Spring fo. ***fissidentoides***

This type form is characterized by its slightly sickle-shaped lanceolate lateral leaves, which are

not auriculate at the base, with a rather blunt apex and a midrib that is apparent but does not reach the apex; and by its auriculate median leaves with a blunt auricle. The axillary leaves are lanceolate.

It occurs in dense and humid forests throughout the length of the east coast of Madagascar (Fig. 3B).

Selaginella fissidentoides (Hooker & Greville) Spring fo. ***ovata*** S. Stefanović & Rakoton-drainibe, fo. nov. TYPE: Madagascar. Est-Centre: forêt d'Analamazaotra, 800 m, *Perrier de la Bâthie 6087* (holotype, P). Figure 1F.

A forma typica foliorum lateralium parte acroscopica semiovata, foliis lateralibus inaequilaterioribus et foliis axillaribus ovatis differt.

These plants are similar to the type form, but differ in having an aspect of more unequal lateral leaves since the acroscopic part of these is semi-ovate (not semi-lanceolate). The axillary leaves are also ovate.

This form occurs, like form *fissidentoides*, on the east coast of Madagascar, but its distribution is limited only to the southern part of the area where the variety is found (Fig. 3B), supporting its segregation as a distinct taxon.

Paratypes. MADAGASCAR. Forêt d'Analamazaotra, Dec. 1905, *d'Alleizette 51* (P, B); Périnet, 2 Sep. 1951, *Benoist 1113* (P); Vondrozo, Tsararano, Dec. 1963, *Bosser 18597* (P); Fanovana, 10 July 1942, *Decary 18131* (P); forêt à feuilles persistantes, bords de Torrents entre Sandrangato et Anosibe, 800–1100 m, 3–7 Nov. 1952, *Léandri & Capuron 1578* (P); forêt orientale sur le Mt. Vatovavy, bassin du Mananjary, 250 m, Oct. 1911, *Perrier de la Bâthie 8260* (BM).

Selaginella fissidentoides (Hooker & Greville) Spring var. ***amphirrhizos*** (A. Braun ex Hieronymus) S. Stefanović & Rakoton-drainibe, stat. nov. Basionym: *Selaginella amphirrhizos* A. Braun ex Hieronymus in Engler & Prantl, Nat. Pflanzenfam. 1 (4): 705. 1902. TYPE: Comores. Comoro-Insel Johanna, 500–1000 m, June–Aug. 1875, *Hildebrandt 1808* (holotype, B; isotype, P).

Nomina nuda of this variety are discussed above in the general observations concerning *Selaginella fissidentoides*.

This more robust variety is characterized by its slightly auriculate lateral leaves, with a mucronate apex and midrib reaching the apex and by auriculate median leaves with an acute auricle curved toward the outside at its apex (at least on the main stem).

It occurs on the Comoros and Nossi-Bé (Fig. 3B),

so the morphological differences from variety *fissidentoides* are supported by geographic distribution.

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